Amendments to the Claims

1. (currently amended) An apparatus for measuring an optical characteristic of a target object, comprising:

a light source configured to produce a light flux;

a light-flux optical system situated relative to the light source and the target object and configured to (i) produce from the light flux a measurement-light flux and a reference-light flux, (ii) direct the measurement-light flux to the target object so as to cause the measurement-light flux to interact with the target object and thus acquire a wavefront profile corresponding to the optical characteristic of the target object, (iii) provide the reference-light flux with a standard wavefront produced by interaction of the light flux with a reference surface, and (iv) establish an interference between the reference-light flux and the measurement-light flux from the target object, the interference having a respective phase distribution;

a phase-state ~~changing~~stepping device situated and configured to move, in stepwise increments, at least one of the target object and the reference surface relative to respective initial positions of the target object and reference surface so as to change, relative to ~~a standard~~an initial phase relation obtained at the respective initial positions, a phase ~~state~~relation of noise light relative to at least one of the reference-light flux and the measurement-light flux from the target object, the stepwise increments and initial positions representing multiple respective phase-state ~~change being~~positions in a range of 0 to 2π;

a phase-modulation device situated and configured to produce a phase modulation of at least one of the reference light flux and the measurement-light flux;

a detector situated and configured to detect interference fringes produced by the interference at ~~any of the various phase states~~the phase-state positions in the range; and

a computer connected to the detector~~and to the phase-state changing device~~, the computer being configured to produce, from the detected interference fringes produced at ~~different~~the respective ~~phase states~~phase-state positions, data concerning the respective phase distributions, and to calculate an average phase distribution from the respective phase distributions.

2. (currently amended) The apparatus of claim 1, wherein the phase-state ~~changing~~stepping device is configured to change the ~~phase state~~phase-state position of the reference~~ light flux~~ surface.

3. (currently amended) The apparatus of claim 1, wherein the phase-state ~~changing~~stepping device is configured to change the ~~phase state~~phase-state position of the ~~measurement light flux~~target object.

4. (currently amended) The apparatus of claim 1, wherein the phase-state ~~changing~~stepping device is configured to change the ~~phase state~~respective phase-state positions of both the ~~reference light flux~~reference surface and the ~~measurement light flux, from the target object,~~target object a same amount relative to the ~~standard~~respective initial positions, while maintaining a constant phase difference between the reference-light flux and the measurement-light flux from the target object.

5. (currently amended) The apparatus of claim 1, ~~further comprising a~~ wherein the phase-modulation device is situated and configured to produce a phase modulation of the measurement-light flux from the target object at each of the phase-state positions in the range.

6. (currently amended) The apparatus of claim 1, ~~further comprising a~~ wherein the phase-modulation device is situated and configured to produce a phase modulation of the reference-light flux at each of the phase-state positions in the range.

7. (previously presented) The apparatus of claim 1, wherein:

the measurement-light flux from the target object has a frequency that is slightly different than a frequency of the reference-light flux; and

the interference is heterodyne interference.

8. (currently amended) The apparatus of claim 1, wherein the phase-state ~~changing~~stepping device is configured to change the ~~phase state~~phase-state position in respective

regular stepped increments, relative to the ~~standard~~respective initial position, so as to provide phase-state positions of 0, π/2, π, and 3π/2 in the range.

9. (currently amended) The apparatus of claim 1, wherein the phase-state ~~changing~~stepping device is configured to change the ~~phase state~~phase-state position in respective regular stepped increments, relative to the ~~standard~~respective initial position, so as to provide phase-state positions of 0, π/4, π/2, 3π/4, π, 5π/4, 3π/2, and 7π/4 in the range.

10. (currently amended) The apparatus of claim 1, wherein the phase-state ~~changing~~stepping device is configured to change the ~~phase state~~phase-state position in respective irregular stepped increments, relative to the ~~standard~~respective initial position, so as to achieve phase-state positions of from 0 to 2π and more than 2π as a whole.

11-20. (canceled)

21. (currently amended) A method for measuring an optical characteristic of a target object, comprising the steps:

(a) directing a measurement-light flux to the target object so as to cause the measurement-light flux to interact with the target and thus acquire a wavefront profile corresponding to the optical characteristic of the target object;

(b) providing a reference-light flux having a ~~standard~~reference wavefront produced by ~~reflection from a standard~~a reference surface;

(c) at initial respective positions of the reference surface and target object collectively representing an initial phase state, establishing a mutual interference between the reference-light flux and the measurement-light flux from the target object;

(d) ~~detecting a respective phase-difference interference pattern produced by the interference~~producing a phase-distribution interference pattern associated with the target object based on phase-shift interference of the reference-light flux and the measurement-light flux from the target object;

(e) moving at least one of the ~~standard~~reference surface and ~~optionally~~ the target object a respective specified distance from ~~a~~the respective ~~standard~~initial position and then repeating

steps (a)-(d), the respective specified distance being appropriate to change a phase state of the at least one of the light fluxes a specified amount in a stepwise manner in a range of 0 to 2π relative to the initial phase state, the steps and initial positions representing respective phase states;

(f) repeating step (e) to obtain respective ~~phase-difference~~phase-distribution interference patterns at the multiple phase states and at the initial positions; and

(g) determining an average ~~phase-difference~~phase distribution ~~of the target object~~ from the respective ~~phase-difference~~phase-distribution interference patterns obtained at the ~~multiple~~ phase states.

22. (currently amended) The method of claim 21, wherein step (e) comprises moving the ~~standard~~reference surface.

23. (previously presented) The method of claim 21, wherein step (e) comprises moving the target object.

24. (currently amended) The method of claim 21, wherein step (e) comprises moving both the target object and the ~~standard~~reference surface while maintaining a constant phase difference between the reference-light flux and the measurement-light flux.

25. (currently amended) The method of claim 21, wherein:

step (e) comprises moving the ~~standard~~reference surface; and

the phase-shift interference performed in step (d) ~~is performed by phase-shift interference involving phase modulation of~~comprises phase-modulating the measurement-light flux.

26. (currently amended) The method of claim 21, wherein;

step (e) comprises moving the target object; and

the phase-shift interference performed in step (d) ~~is performed by phase-shift interference involving phase modulation of~~comprises phase-modulating the reference-light flux.

27. (original) The method of claim 21, further comprising the step of providing the measurement-light flux with a frequency that is slightly different than a frequency of the

reference-light flux so as to establish, in step (c), a heterodyne interference between the reference-light flux and the measurement-light flux.

28. (currently amended) The method of claim 21, wherein, in step (e), the at least one of the target object and the ~~standard~~reference surface is moved relative to the respective initial positions so as to ~~change the~~obtain phase ~~state~~states in ~~a respective increment~~respective regular increments, relative to the ~~standard~~initial phase state, of 0, $\pi/2$, π, and $3\pi/2$.

29. (currently amended) The method of claim 21, wherein, in step (e), the at least one of the target object and the ~~standard~~reference surface is moved relative to the respective initial positions so as to ~~change the~~obtain phase ~~state~~states in ~~a respective increment~~respective regular increments, relative to the ~~standard~~initial phase state, of 0, $\pi/4$, $\pi/2$, $3\pi/4$, π, $5\pi/4$, $3\pi/2$, and $7\pi/4$.

30. (currently amended) The method of claim 21, wherein, in step (e), the at least one of the target object and the ~~standard~~reference surface is moved relative to the respective initial positions so as to ~~change the~~obtain phase ~~state by one or more~~states in respective irregular increments, relative to the ~~standard~~initial phase state, of from 0 to 2π and more than 2π as a whole.

31. (previously presented) The method of claim 21, wherein the target object is an optical element.

32. (currently amended) ~~An optical element, having an optical characteristic measured using the~~The method of claim 21, wherein the optical characteristic is a wavefront aberration.

33. (canceled)

34. (previously presented) The method of claim 72, wherein the step of reflecting the measurement-light flux comprises providing a mirror downstream of the target object so as to reflect the measurement-light flux.

35. (currently amended) The method of claim 72, wherein step (e) comprises moving both the target object with reflection member and the ~~standard~~reference surface while maintaining a constant phase difference between the reference-light flux and the measurement-light flux.

36. (currently amended) The method of claim 72, ~~wherein:~~wherein step (d) further comprises modulating the measurement-light flux~~; and in step (e) the detected interference is a phase-shift interference~~.

37. (currently amended) The method of claim 72, ~~wherein;~~wherein step (d) further comprises modulating the reference-light flux~~; and in step (e) the detected interference is a phase-shift interference~~.

38-45. (canceled)

46. (currently amended) An apparatus for measuring an optical characteristic of a target object, comprising:

a light source configured to produce a light flux;

a light detector;

an optical system situated relative to the light source and the target object and configured to (i) produce from the light flux a measurement-light flux and a reference-light flux, (ii) direct the measurement-light flux to the target object so as to cause the measurement-light flux to interact with the target object and thus acquire a wavefront profile corresponding to the optical characteristic of the target object, (iii) ~~direct~~interact the reference-light flux ~~to reflect from~~with a ~~standard~~reference surface so as to provide the reference-light flux with a ~~standard~~reference wavefront, (iv) establish an interference between the reference-light flux from the ~~standard~~reference surface and the measurement-light flux from the target object, and (v) direct the interfering reference-light flux and measurement-light flux to the detector;

~~an~~a first actuator situated and configured to move the ~~standard~~reference surface and optionally also the target object a respective specified distance ~~relative to~~in a stepwise manner from a respective ~~standard~~initial phase-state location, the respective specified distance being

appropriate to change a phase state of the at least one of the light fluxes a specified amount in a stepwise manner in a range of 0 to 2π relative to the initial phase-state location;

a second actuator situated and configured to produce a phase modulation between the reference-light flux and the measurement-light flux;

a phase-detection device connected to the detector and configured to detect respective phase differences in the detected light~~, at the various locations resulting from movement, achieved by the actuator, of the standard surface and optionally the target object over the respective specified distance~~ at each of the specified distances based on the phase-modulation; and

a computer configured to determine respective phase distributions from the respective phase differences at each of the specified distances and to calculate, from the respective phase distributions, an average phase distribution, the average phase distribution corresponding to a measurement of the optical characteristic.

47. (previously presented) The apparatus of claim 74, wherein the optical characteristic is a surface profile of the target object.

48. (currently amended) The apparatus of claim 74, wherein the actuator is configured to move the target object relative to the respective ~~standard~~initial phase-state location.

49. (currently amended) The apparatus of claim 74, wherein the actuator is configured to move the ~~standard~~reference surface relative to the respective ~~standard~~initial phase-state location.

50. (currently amended) The apparatus of claim 74, wherein the actuator is configured to move both the ~~standard~~reference surface and the target object relative to the respective ~~standard~~initial phase-state locations while maintaining a constant phase difference in the interfering reference-light flux and measurement-light flux.

51. (canceled)

52. (previously presented) The apparatus of claim 75, wherein the optical characteristic is a wavefront aberration of the target object.

53. (currently amended) The apparatus of claim ~~75~~76, wherein the first actuator is configured to move the target object, the reflection member, and the ~~standard~~reference surface while maintaining a constant distance between the target object, the reflection member, and the ~~standard~~reference surface.

54. (currently amended) The apparatus of claim ~~75~~76, wherein the first actuator is configured to move both the target object and the reflection member while maintaining a constant distance between the target object and the reflection member.

55. (canceled)

56. (original) The apparatus of claim 46, wherein the target object is a lens element.

57-59. (canceled)

60. (previously presented) The apparatus of claim 75, wherein the target object is a lens element.

61-63. (canceled)

64. (previously presented) The apparatus of claim 1, wherein:

the optical characteristic pertains to a surface profile of a reflective target surface of the target object; and

the light-flux optical system is configured to direct the measurement-light flux to the target surface so as to reflect from the target surface, and to establish an interference between the reference-light flux and the measurement-light flux reflected from the target surface.

65. (previously presented) The apparatus of claim 1, wherein:

the optical characteristic pertains to a wavefront aberration profile of the target object; and

the light-flux optical system is configured to direct the measurement-light flux to the target object so as to be transmitted through the target object, and so as to establish an interference between the reference-light flux and the measurement-light flux transmitted through the target object.

66. (previously presented) The method of claim 31, wherein the optical element is a lens element.

67. (currently amended) The method of claim ~~32~~31, wherein the optical ~~characteristic~~element is a ~~wavefront aberration~~mirror.

68. (currently amended) The method of claim ~~32~~21, wherein the ~~optical element comprises a~~ target object ~~surface having a surface profile measuring using the method of claim 21~~is an optical system comprising multiple optical elements.

69. (previously presented) The method of claim 21, wherein:

the optical property pertains to a surface profile of a reflective target surface of the target object; and

step (a) comprises directing the measurement-light flux to the target surface so as to be reflected from the target surface.

70. (previously presented) The method of claim 21, wherein:

the optical characteristic pertains to a wavefront-aberration profile of the target object; and

step (a) comprises directing the measurement-light flux to the target object so as to be transmitted through the target object.

71. (previously presented) The method of claim 70, wherein, in step (a) the measurement-light flux is directed to the target object so as to be transmitted in a first direction through the target object to a reflection member.

72. (previously presented) The method of claim 71, further comprising reflecting the measurement-light flux, that has been transmitted in the first direction through the target object, so as to cause the measurement-light flux to return through the target object in a second direction.

73. (currently amended) The method of claim 72, wherein step (e) comprises moving the ~~standard~~<u>reference</u> surface and optionally the reflection member a respective specified distance from a respective ~~standard~~<u>initial phase-state</u> position.

74. (previously presented) The apparatus of claim 46, wherein the optical system directs the measurement-light flux to the target object so as to cause the measurement-light flux to reflect from a target surface of the target object.

75. (previously presented) The apparatus of claim 46, wherein the optical system directs the measurement-light flux to the target object so as to cause the measurement-light flux to pass through the target object.

76. (previously presented) The apparatus of claim 75, further comprising a reflection member situated relative to the target object such that measurement light transmitted in a first direction through the target object reflects from the reflection member and returns via a second direction, opposite the first direction, through the target object to interfere with the reference-light flux.

77. (currently amended) The apparatus of claim 75, wherein the <u>first</u> actuator is situated and configured to move the ~~standard~~<u>reference</u> surface and optionally at least one of the reflection member and target object a respective specified distance relative to a respective ~~standard~~<u>initial phase-state</u> location.

78. (new) The apparatus of claim 1, wherein the light-flux optical system provides the reference-light flux with a reference wavefront by directing the reference-light flux to a Fizeau surface from which the reference-light flux acquires the reference wavefront.

79. (new) The apparatus of claim 1, wherein the phase-modulation device produces the phase-modulation by moving at least one of the target object and the reference surface.

80. (new) The apparatus of claim 1, wherein the phase-state stepping device and the phase-modulation device are the same device.

81. (new) The apparatus of claim 1, wherein the phase-state stepping device and the phase-modulation device are separate devices.

82. (new) The apparatus of claim 1, wherein the stepwise increments are regular.

83. (new) The apparatus of claim 1, wherein the stepwise increments are irregular.

84. (new) The apparatus of claim 1, wherein the target object is a lens.

85. (new) The apparatus of claim 1, wherein the target object is a mirror.

86. (new) The apparatus of claim 1, wherein the target object is an optical system comprising multiple optical elements.